RESPONSE FROM

MASTEN SPACE SYSTEMS, INC.

TO NASA AMES RESEARCH CENTER

ON COMMERCIAL REUSABLE SUBORBITAL SPACEFLIGHT SERVICES

Technical point of contact

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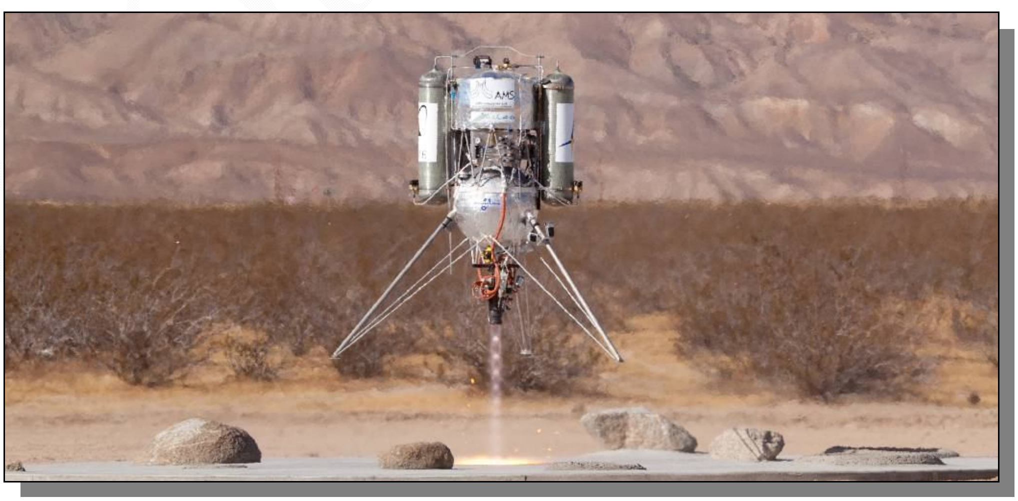
Abstract

Masten Space Systems is developing a line of reusable suborbital small payload launch vehicles to provide the premier suborbital research environment. Our flexible unmanned craft allow Masten Space Systems to provide access to interesting altitudes, reduced gravity, microgravity, and nanogravity for payloads beginning in the third quarter of 2010.



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1 Expression of Interest

Masten Space Systems is very interested in providing the launch/payload services outlined in NASA's CRuSR RFI. The company is developing a series of small reusable launch vehicles that will provide access to space in 2011, and altitudes approaching 100,000 feet beginning in Q3 of 2010. The unmanned state of our launch vehicles allows us to provide a premium environment to payloads – allowing us to simulate reduced gravity environments or provide premium microgravity and nanogravity for portions of the flight.

2 Requested Information

2.1 Programmatic Information

Masten Space Systems is developing a series of fully reusable vertical takeoff and vertical landing (VTVL) launch vehicles designed to provide access to space. This line of vehicles is currently comprised of two vehicles with two additional vehicles on target for completion before the end of the 2010.

Xombie (the vehicle that won second place in level one of the NASA funded Northrop Grumman Lunar Lander Challenge X Prize) is being used for low speed and low altitude testing. Xoie (the winner of level two of the Lunar Lander Challenge) is being reconfigured for high altitude and high speed flights. The company expects Xoie to begin higher altitude and higher speed flights in the third quarter of 2010. Xoie is expected to be able to carry a 10kg payload to approximately 30 kilometers (or 100,000 feet) according to current models.

One of the company's major tasks in 2010 is the development of a 3000lbf engine that will be mounted on a vehicle similar to Xoie. The new vehicle – Foxie - should begin flights in Q4 2010. Foxie is expected to be able to carry a 10kg payload above 30km (100,000 ft).

The next vehicle in development for Masten Space Systems is currently nicknamed Xogdor and is powered by the same 3000lbf engine that powers Foxie but with larger tanks. Current models show that Xogdor can take a 47kg payload to 100 kilometers. Xogdor is expected to begin flying in 2011.

2.1.1 Service Availability Timeline and Pricing

We expect to begin flights capable of carrying a customer's payload in the third quarter of 2010. These flights will initially be approximately 30 km and will gradually increase in both payload capacity and altitude. We are targeting pricing within a range of $20,000 and $150,000 per flight depending on launch location, insurance, altitude, range fees, etc. There may be launch opportunities prior to this date on certain test vehicles. Pricing for such flights is negotiated on a case by case basis.

Vehicles capable of carrying approximately 50kg above 100km should be available sometime in 2011. Rough order of magnitude pricing for this service may be available by the end of 2010.

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2.1.2 Regulatory Requirements

Xoie, Foxie and Xogdor are all designed to fly within the Federal Aviation Regulations for Unmanned Rockets (CFR 14 Part 101). This means that no Launch Permit or License is required for these vehicles. As a part of the FAR 101 compliance process, the FAA will be requested to provide authorization for launches into controlled airspace. The process includes consultation with the Office of Commercial Space Transportation (FAA/AST), and including safety review. XA-1.0 will require a Launch License in order to carry commercial payloads.

The company intends on flying at its Mojave, CA facility as much as possible. It is not clear at this time whether it will be possible to fly to 100km at the Mojave Air and Spaceport. The company has begun discussions with Spaceport America in New Mexico and Mid-Atlantic Regional Spaceport (MARS) at Wallops Island, Virginia.

While not required under FAR 101, we will maintain liability coverage to a maximum of $3 million per incident.

2.1.3 Partnering Opportunities

One of Masten Space System's goals is to significantly lower the integration and customization overhead associated with building and flying a payload. There are three categories that significantly affect the cost of development and integration: contracting, custom physical interfaces, and pre-flight testing. The company is already working to reduce the cost of payload to vehicle interfaces by adhering to existing standards and providing as many on board services as possible (data, power, telemetry, etc). Clear and standard interface specifications greatly reduce the time needed for pre-flight testing but more work can be done to reduce this time. The final, and in some cases most significant, cost/time component is the overhead of the launch contract itself. Wherever possible the company would like to move to a standardized GSA-like procurement process. The company would like to work jointly with NASA to reduce the cost and time associated with each of these areas.

2.2 Technical Information

2.2.1 General Flight Profile Information

Masten Space Systems' vehicles take off and land vertically in the same place they launch from. In the Lunar Lander Challenge, Xoie and Xombie both demonstrated sub 24cm (10in) landing accuracy. Flight profile consists of launch, acceleration to Mach 0.9 throughout the majority of atmospheric resistance, then going full throttle before shutting off the engine. During parabolic coast phase the payload experiences microgravity. As the vehicle descends back into to the atmosphere and gains speed the coast phase ends. At this point he rocket stabilizes itself and falls towards the ground engine first before the engine re-lights and lands the vehicle on the same pad used for takeoff. Flight profiles have some flexibility for payload specific needs and are assessed on a per payload basis.

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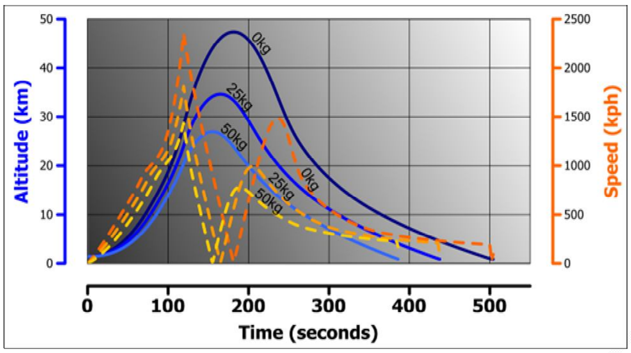
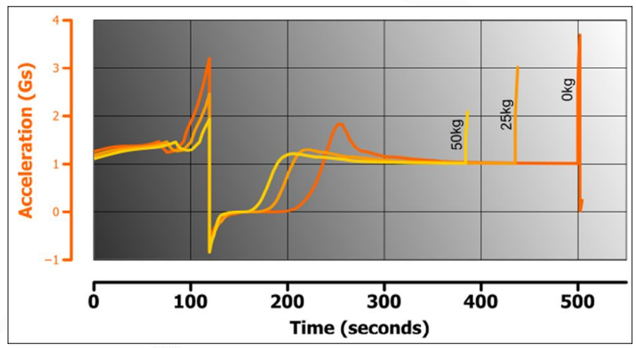
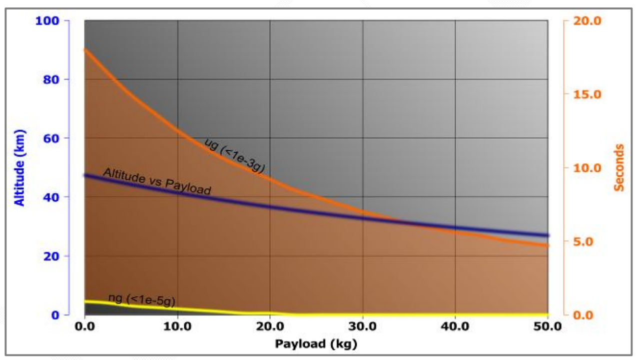
Along with microgravity and nanogravity, Masten Space Systems can offer reduced gravity for simulated lunar or martian environments. This can be useful for the testing of components intended to operate in either location. Please note that the flight trajectories listed below would need to be altered and should be considered an "add-on" service.

2.2.1.1 Xoie

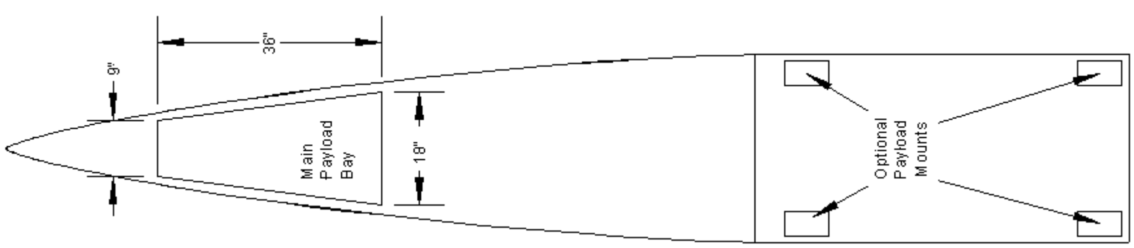
Xoie may be able to reach just shy of 100,000 ft altitude. The following charts describe current simulated payload capability, how that affects altitude, and the amount of microgravity that profile allows:







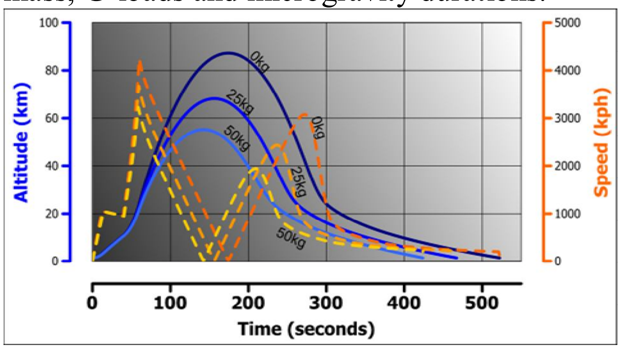
Xoie is the company's first vehicle to use an aeroshell. Payload placement slots are available in both the forward section of the nose cone or in smaller areas toward the aft end of the vehicle.

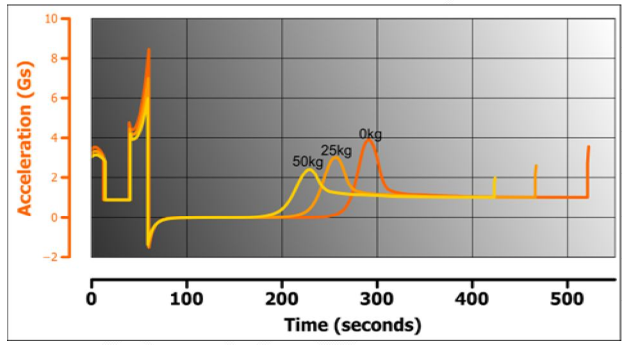


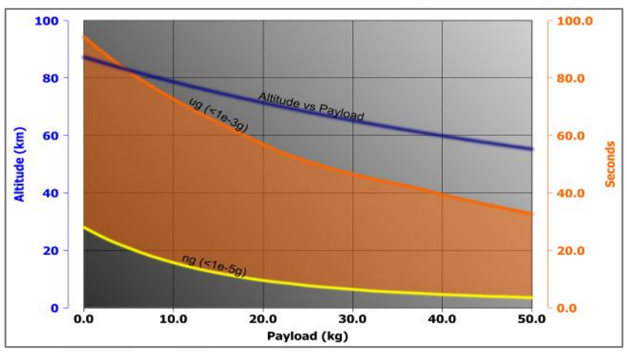
As currently designed, Xoie, Foxie, and Xogdor's airframe allow for P-POD Cubesat carriers and single ESPA ring mounts as a standard payload format. Lower bays are limited in size and do not adhere to any existing payload interface standard. Additional R&D would be needed to accommodate the Mid-Deck Locker format.

2.2.1.2 Foxie

Foxie is a version of Xoie with a 3000lbf engine. Therefore payload interfaces, mass and size allocations are the same as Xoie. The following represent Foxie's simulated altitude, payload mass, G-loads and microgravity durations:

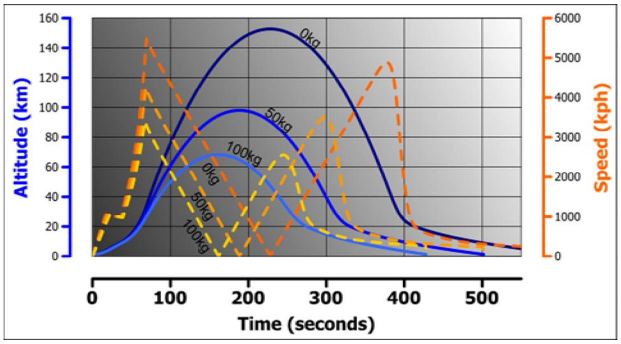


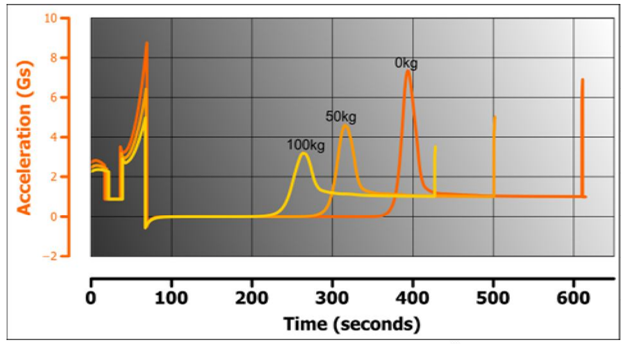


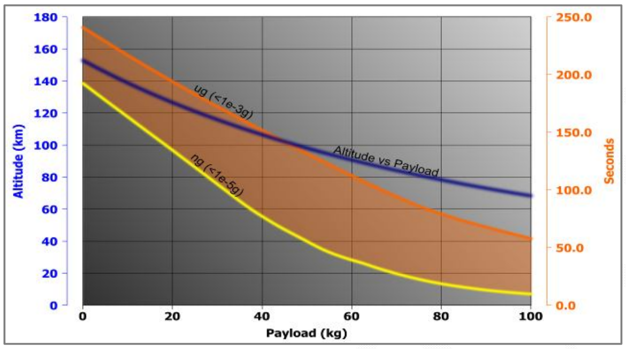


2.2.1.3 Xogdor

Xogdor will be Masten Space System's first attempt at reaching above 100km. Using the same engines used on Foxie but with larger tanks, Xogdor is a final release candidate for the full XA-1.0 production vehicle. Since Xogdor's design is still in development, including a diagram here would be misleading. Using existing simulations and knowledge from Xoie the company can provide preliminary flight profile data:







2.2.1.4 XA-1.0

In 2011 Xogdor will be scaled up to the full production vehicle: XA-1.0. While its exact design and performance are still notional, it will be capable of ESPA, Mid-Deck Locker, and multiple-PPOD payload standards and will provide data storage, ground telemetry, power, and pressurized payload space.

2.2.2 Launch/Landing Sites

Masten Space Systems is currently based at Mojave Air and Spaceport in Mojave, CA. The company is also in discussions with Spaceport America (New Mexico) and Mid-Atlantic Regional Spaceport (Virginia) for additional flight operations. Ground operations and infrastructure requirements are minimal enough that the company can fly almost anywhere that has reasonably clear air traffic and minimal exposure to populated areas. Suitability of a launch or landing site is determined by cost of insurance and flight rate.

2.2.3 Launch Windows and Flight Rates

Launch windows are available on demand with very short lead time. Turn time between flights is limited only by refueling time, air space availability, and payload integration. Air space availability is an unpredictable component that is affected by existing Federal Range policies and capabilities.

2.2.4 Data Rate for Telemetry Data

Masten Space Systems attempts to provide secure downlink telemetry at as high a data rate as possible. As vehicles go higher this proves to be more difficult. Each vehicle employs three channels of telemetry data: vehicle and safety data, payload status and control, and realtime

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payload data transfer. Flight telemetry and payload status/command telemetry require low data rates, low latency, and bi-directional traffic flow. Real-time payload data is normally very high bandwidth and unidirectional. For most of 2011 the company will only be able to provide flight control and safety telemetry. As Xogdor becomes available it will provide payload status and command channels. Full bandwidth downlink telemetry for payload data will be available sometime in 2011.

2.2.5 Payload Environment

Xoie, Foxie and Xogdor all use the same basic aeroshell and payload bay design. The upper payload bay is roughly conical with a base diameter of 18”, top diameter of 9”, and a height of 36”. There are payload adapter facilities at the base of the vehicle and along the fuselage as well. Use of these additional facilities may require additional NRE.

Optional power is available to the payload bay 12VDC or 24VDC and may reduce payload mass available or total altitude for your payload mass.

2.2.6 Data Storage Capabilities / Constraints

Xoie and Foxie will not provide data storage interfaces. Xogdor’s data storage will be solid state devices such as SD or CompactFlash. Storage protocols will be industry standards such as USB 2.0 or iSCSI.

2.2.7 Internal Experiment Mounting Capabilities

Payload mounting specifications and CAD files will be available for Xoie and Foxie by Q3 2010. Interface specifications for Xogdor will be available prior to 2011.

2.2.8 Fields of View

Neither Xoie nor Foxie have standard mechanisms for providing fields of view outside the vehicle. Xogdor will have windows with interchangeable materials as needed by the customer. Vehicles following Xogdor will have the ability to open the payload bay entirely to provide the payload an unobstructed view. The field of view available for these vehicles has not been determined yet.

2.2.9 Attitude Constraints

All Masten Space Systems vehicles can be pointed ± 2.5 degrees in any direction during the coast phase of flight trajectory. The coast time can be interpreted as approximately that under sensed accelerations of 1e-3 of gravity as shown in the charts in Appendix A. The company intends on developing free floating and/or vibration isolation mechanisms to give payloads a sub-arc-second pointing accuracy sometime in 2011 or 2012 depending on demand. The company may be interested in jointly developing solutions for recoverable and reusable fine-grained pointing systems.

2.2.10 Earth/Space Viewing Capabilities and Constraints

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All vehicles can be pointed in any direction after engine shut-off and before relight, or throughout the entirety of the coast phase of flight. The company does require proof that any payload customer flying an earth observation mission has the appropriate NOAA licenses for observations that may include nations other than the United States.

2.2.11 Potential for Window Mounted Experiments

The company does not plan on providing windows in either Xoie or Foxie but will provide some window mounted payload slots with Xogdor. This plan could change if there was significant early demand.

2.2.12 Expected Cabin Working Environment

All payloads will have access to the outside ambient conditions. Current and planned vehicles do not have plans for pressurized payload bays but can carry experiments that are self-pressurized.

2.2.13 Advantages of Unmanned Flight

There are distinct advantages to unmanned suborbital flights using our VTVL vehicles.

- Natural movement by crew means that it is nearly impossible to provide nano-scale gravity (less than 1e-5g) of any reliably useful duration.
- The mass of pressure vessel, life support, and the crew itself means that total mission mass is much higher, increasing costs and limiting altitude.
- The company fully expects regular flights above 200km by 2012. Flights to that altitude put g-load demands on the vehicle that manned vehicles may not be able to handle. Few, if any, of our manned competitors are capable of that altitude that early.
- Turnaround time between flights is not limited by crew and passenger loading/unloading or cabin reconfiguration.

2.3 Operations Information

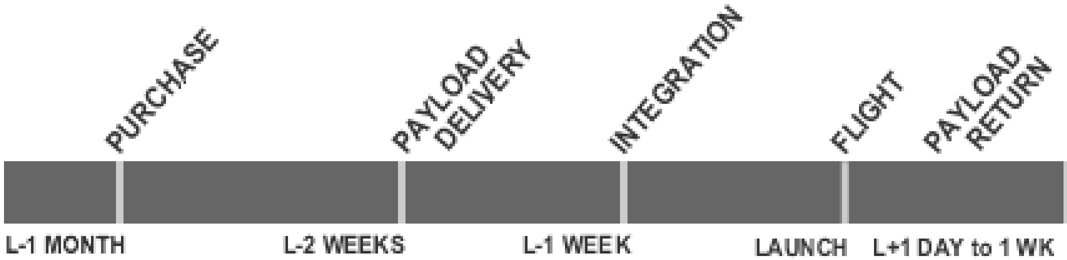
Part of the company’s strategy is to lower the operational costs of not only operating the vehicle but of on-boarding a customer and integrating the payload. A fast turn around time for the vehicle doesn’t accomplish much if payloads require a large amount of integration time. Using existing interface standards and off the shelf components should enable payloads to be delivered, tested and be ready for flight within hours.

Where a customer requires immediate pre and post flight access to the payload there may be additional costs associated with ground support crew necessary to facilitate that access and to ensure safety.

2.3.1 Integration of Science Payloads

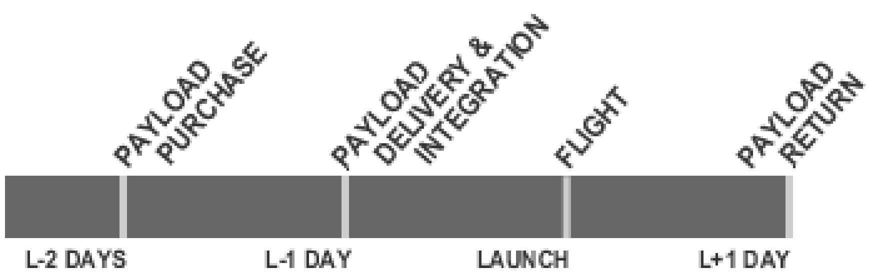
NASA will be provided detailed CAD drawings and interface specifications for Xoie and Foxie by Q3 2010. For smaller payloads, we will make every effort to combine compatible payloads. Contact Masten Space Systems business development for ride sharing options.

2.3.2 Expected and Standard Timelines

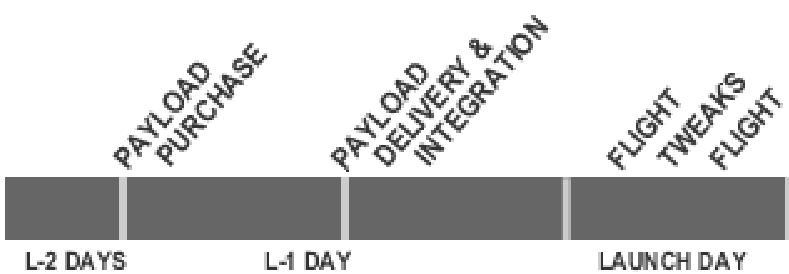


Nominal Timeline, Single Flight

Nominal Timeline, Multiple Flights



Expedited Timeline, Single Flight



Expedited Timeline, Multiple Flights

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For expedited timelines, simple payloads could arrive on the same day as flight. Any unforeseen integration work necessary could expand that timeline, but simple bolt-down payloads fitting the Masten Space Systems payload form factor will provide extra flexibility.

2.3.3 PI and Experiment Integration Plan

By standardizing payload interfaces and simplifying testing as much as possible the company hopes to reduce the amount of in depth training and integration. Much of this information will be available on the company's website as either screencasts or pre-recorded Webex demonstrations.

Currently the only two tests the company requires before flight are a negative 1 atmosphere pressure gradient test and a basic electrical systems test if external power is being used. Payload developers should provide basic documentation showing risks the payload exposes the vehicle to such as electrical shorts, fire potential, structural failure, etc.

2.3.4 Launch Opportunities

Current turn time between flights is about one hour (excluding any payload changes). Limitations on cadence and flight window availability are weather, air space, and launch site. Xoie, Foxie, and Xogdor can all fly in up to 20 mph cross wind. Each launch site comes with its own set of restrictions on air space and range imposed schedules. Mojave Air and Space Port has regular air traffic which puts reasonable limits on actual launch time. Spaceport America (New Mexico) works jointly with White Sands Missile Range which handles schedule of flights through the range and can pre-empt the schedule for Government use of WSMR.

2.3.5 Launch Sites

Masten Space Systems is currently operating out of Mojave Air & Space Port in Mojave, CA. We expect to launch Xoie out of Mojave, CA beginning in Q2 2010. Mojave is currently limited to 10,000 ft and below but the company is actively working with FAA and the Spaceport to increase that limit.

The company is also in discussions with Spaceport America (New Mexico) and MARS (Wallops Island, VA) as well. The company will keep NASA informed of any changes to launch sites or operations.

2.3.6 Opportunities for modifications of any standard services

Flight operations in 2010 are preliminary in nature which limits the number of standard modifications. The company is interested in working with customers on modifications but these will require additional costs and will impact other schedules. A good deal of work in late 2010 and 2011 will be spent developing this standard menu of flight options. They may include items such as:

- Custom trajectories
- Payload ejection
- Open payload bay doors

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- High speed data storage
- Sub-arc second vehicle isolation platform
- Nano-gravity vehicle isolation system
- Expendable upper stage for nanosat (sub 10kg) orbital capability

2.3.7 Masten Space Systems Point of Contact for Additional Information

David Masten
CEO
dmasten@masten-space.com
415.244.9171

Michael Mealling
CFO / VP of Business Development
mmealling@masten-space.com
678.640.6884

2.4 Pricing Information

Pricing for flights up to 30km (100,000 ft) in 2010 are between $20,000 and $150,000 depending on altitude, insurance, location, etc.

This price does not include extensive (i.e. greater than 1 man-week) payload development or integration labor or extensive on-site launch day operations.

Additional costs are billed at the following rates:

Integration labor	$2000 per day per person
Custom Launch Ops	$2000/day per additional staff above base ops requirement
Consulting	$300/hr (negotiated)

On-boarding a basic payload involves a certain basic level of effort. More advanced payloads may require additional effort more in-line with a joint R&D or consulting agreement.

The company reserves the right to change pricing at any time.

2.4.1 Approximate Cost for Accommodation

All basic flight costs are covered in the pricing discussion above. The company reserves the right to change pricing at any time.

2.4.2 Approximate Cost for Operations

All basic flight costs are covered in the pricing discussion above. The company reserves the right to change pricing at any time.

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2.4.3 Any Other Approximate Costs to NASA Associated with Flying a CRuSR Experiment

Costs associated with travel to the company's facilities for inspections, payload delivery, flight day operations, etc are not covered by the company or included in the above basic flight price.

3 Offer of Further Assistance And On-Site Invitation

3.1 Meetings at Customer's Location

Masten Space Systems is interested in participating in additional meetings (at ARC or otherwise) whether they include industry members and other interested organizations or not.

3.2 Site Visit

Site visits provide a unique opportunity to examine vehicles up close, dry fit components, and see flight operations, and review safety procedures in action. Direct access to engineers and hardware is invaluable to accelerating the time to flight for the payloads NASA has in mind for 2010. A site visit by the CRuSR team would involve several distinct discussion tracks:

- Programmatic – Details of on-boarding a PI and their payload, prioritization of potential add-on services, timelines for 2011, contracting options
- Operational – Actual demonstrations of turn around time, payload access processes, impacts on operations by payload owners
- Integration – Dry runs of actual payloads to existing mounting hardware, power and telemetry discussions, alternative payload placement
- Safety – In depth discussion of payload safety and safety of customer's staff if launch day operations are required

The company feels that face to face discussions between experts in each of these areas is crucial to being able to fly payloads in 2010.

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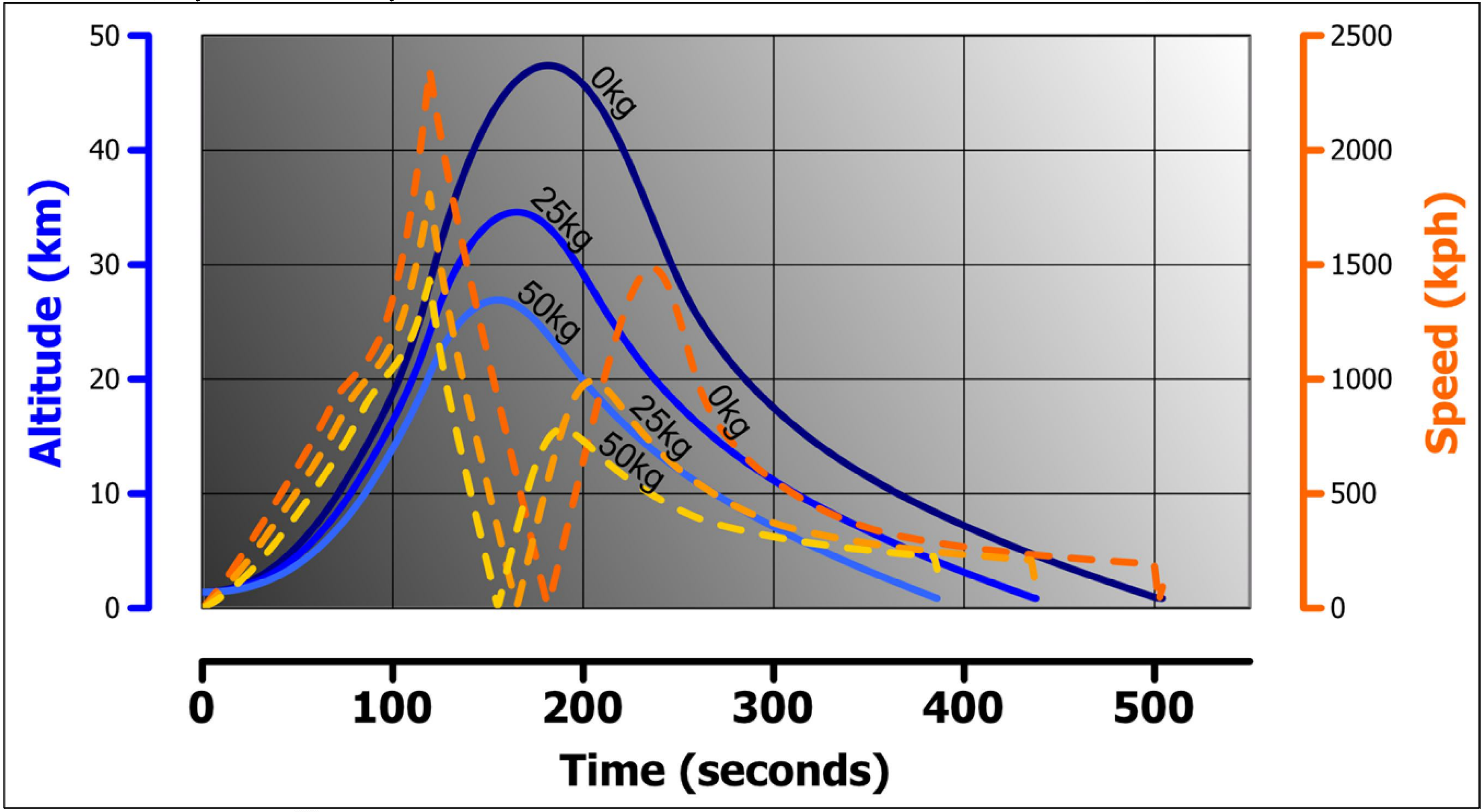
Appendix A - Detailed Flight Profile Models

Xoie

Xoie Altitude, Payload and Velocity



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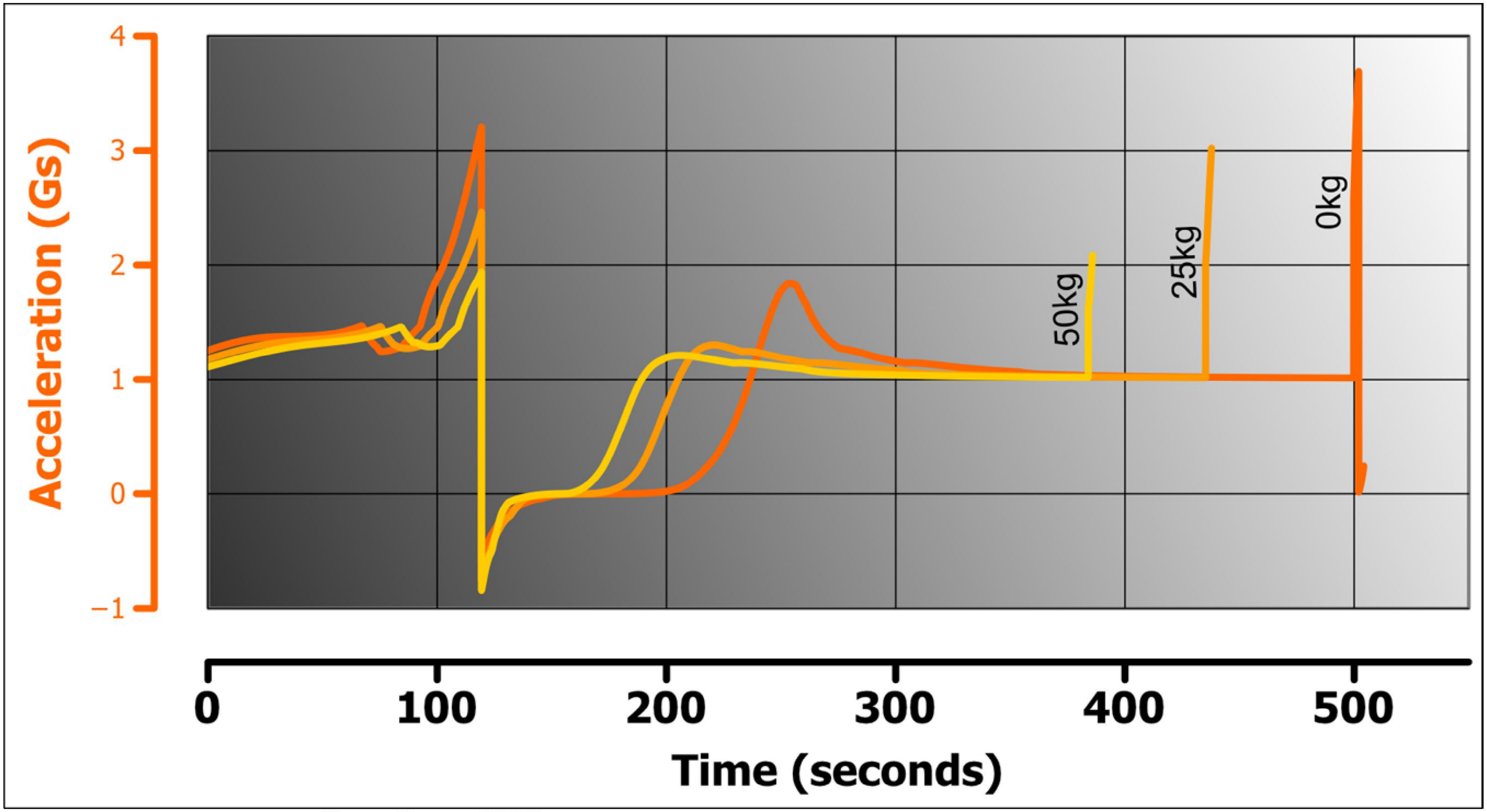
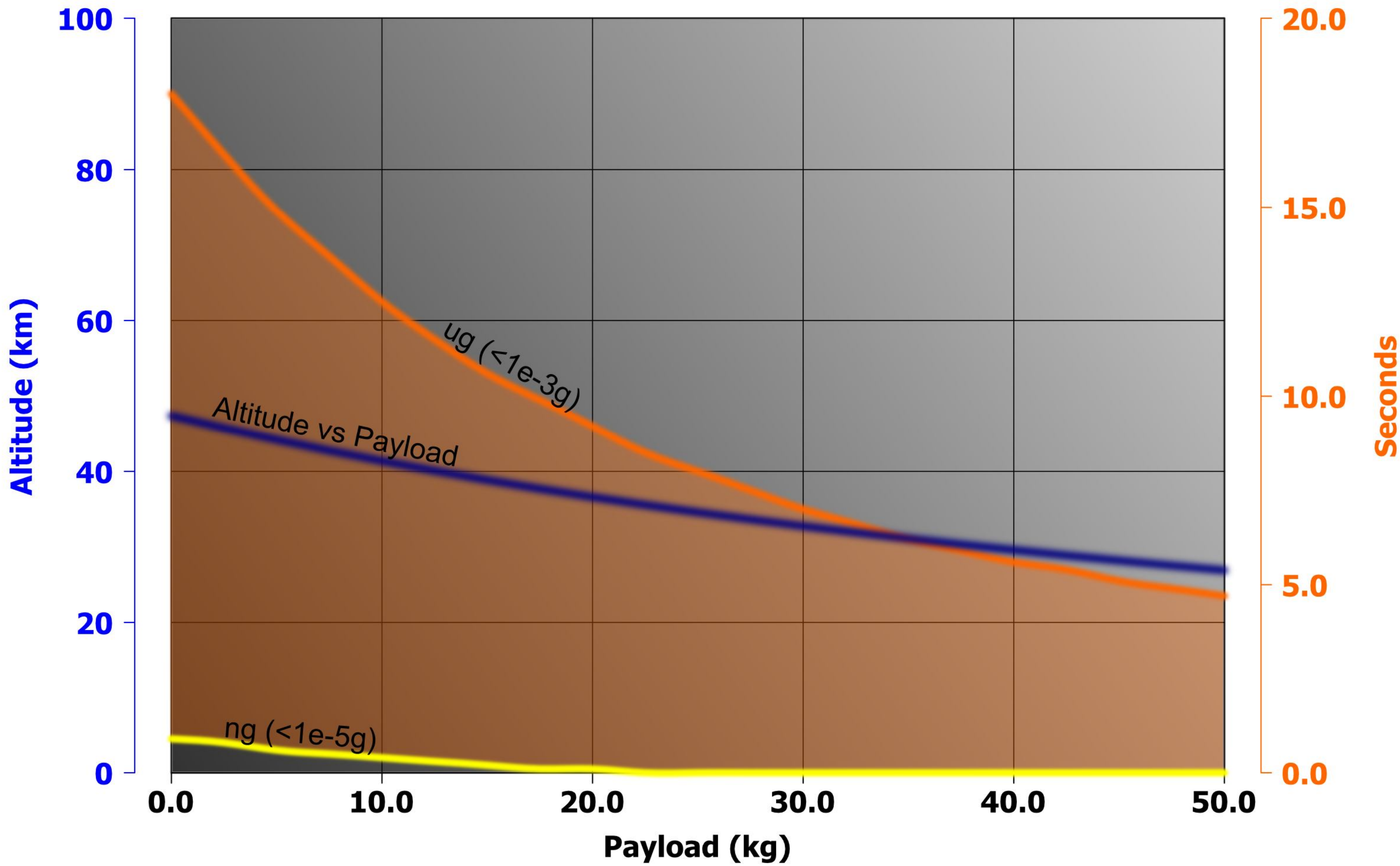
Xoie Acceleration in Gs



Xoie Available Microgravity



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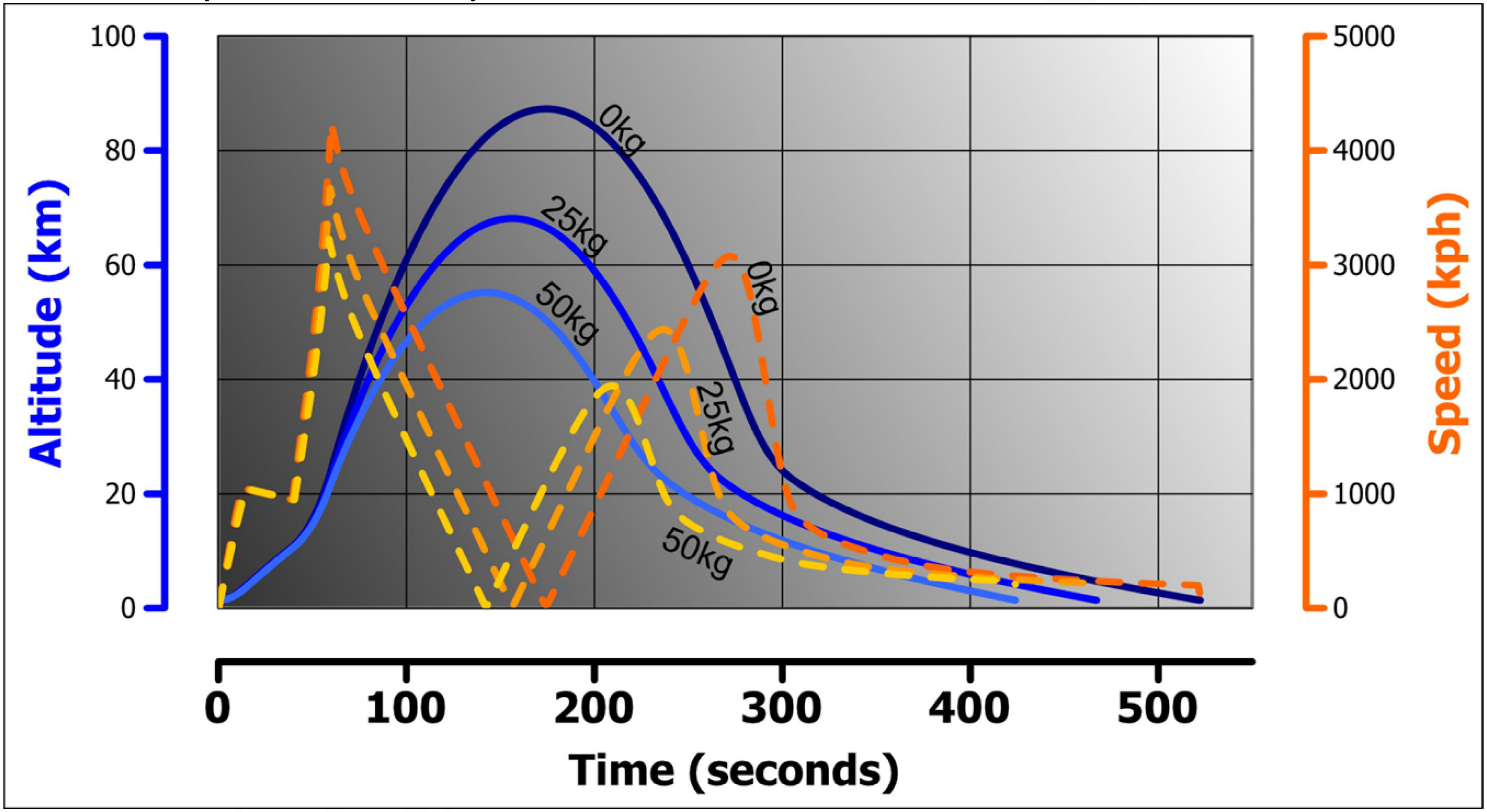
Foxie

Foxie Altitude, Payload Mass, and Velocity



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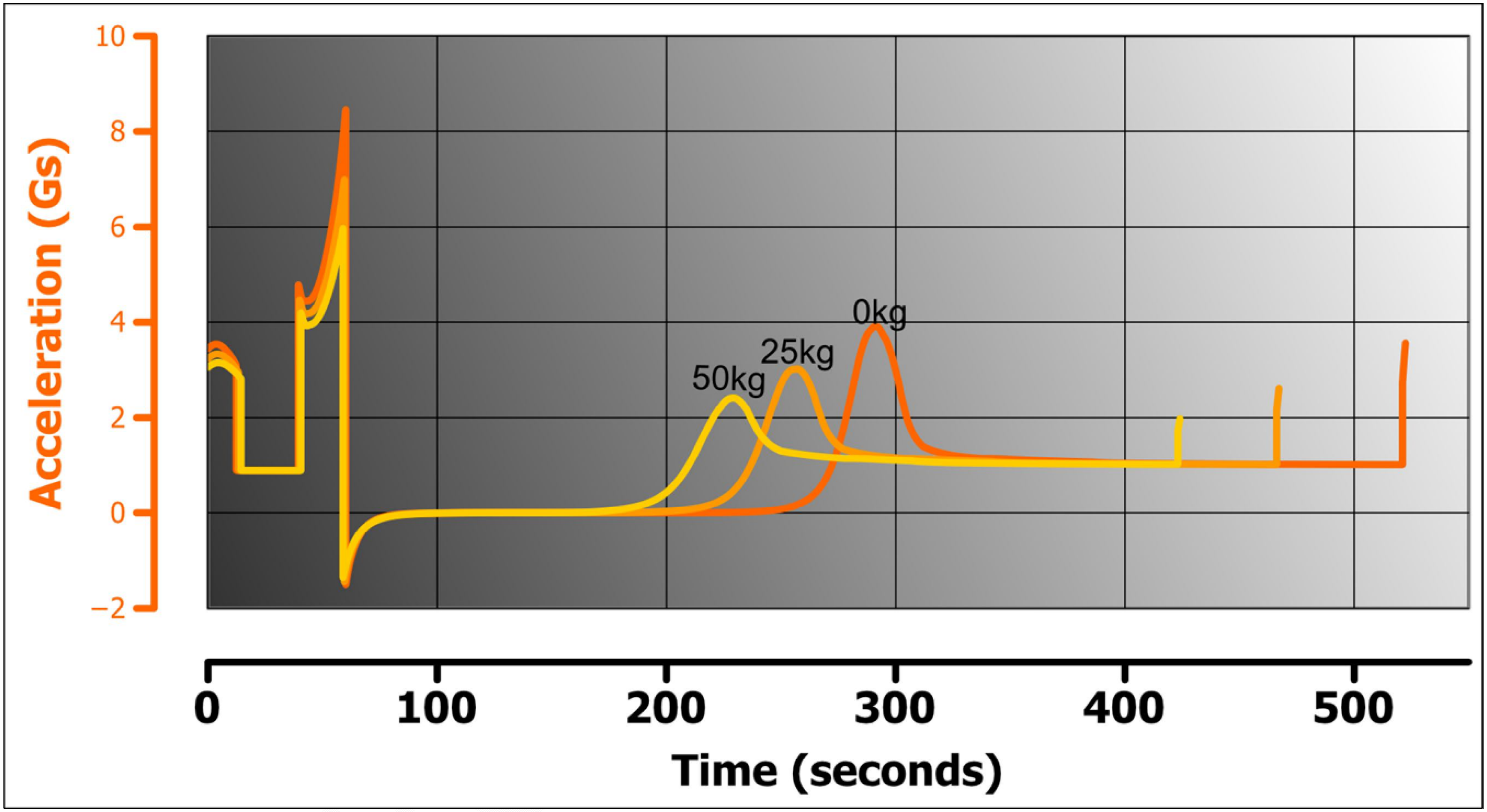
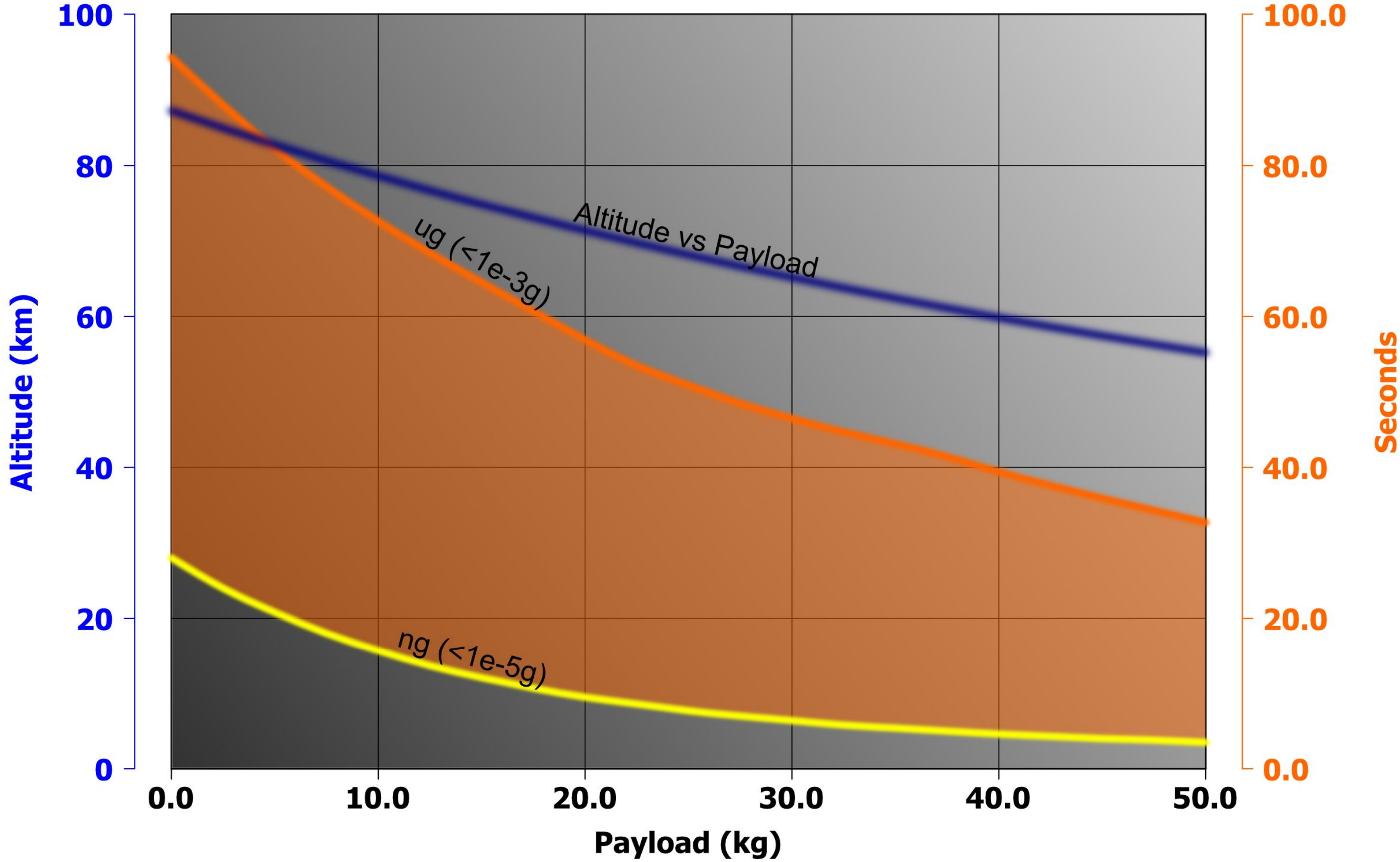
Foxie Acceleration in Gs



Foxie Available Microgravity



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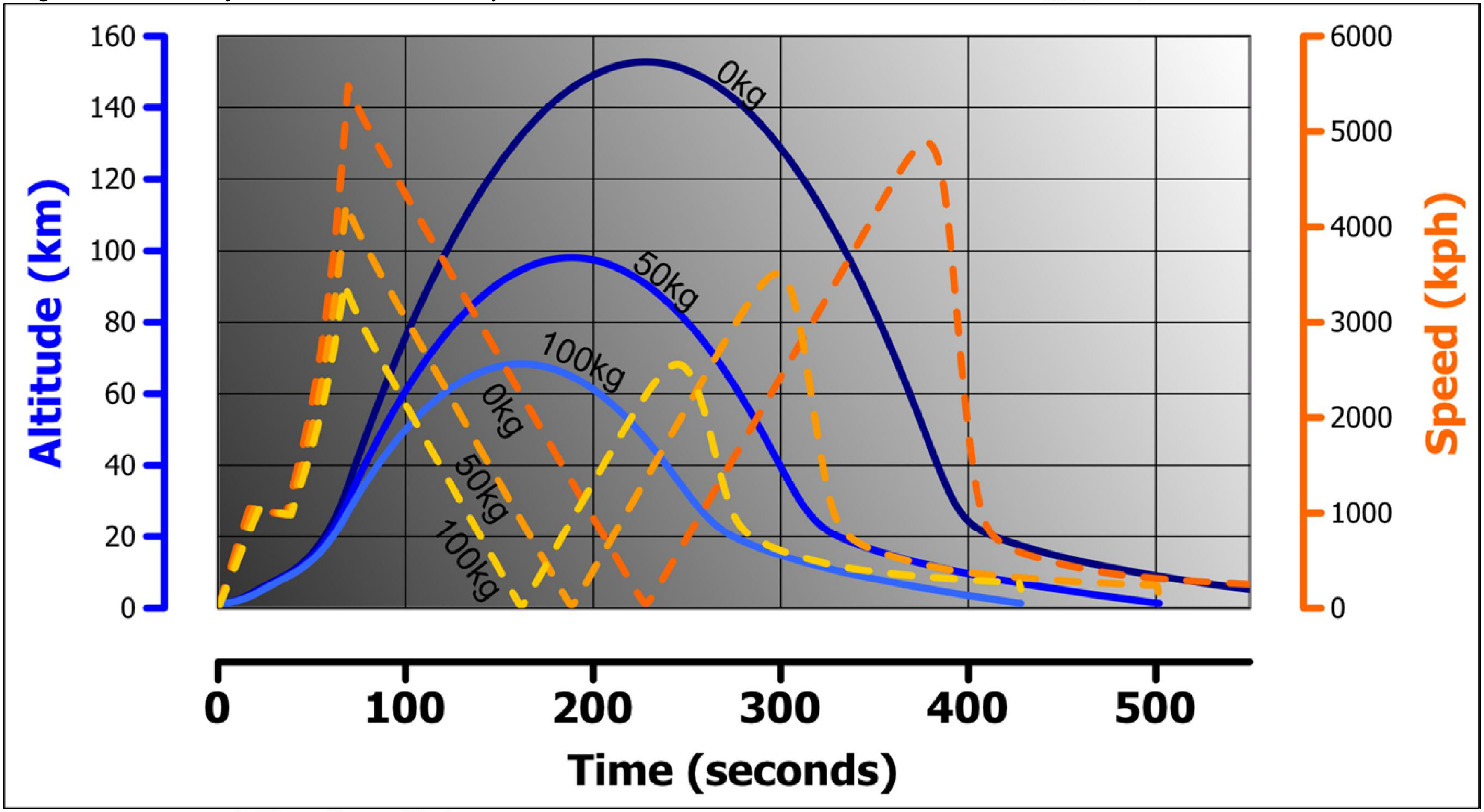
Xogdor

Xogdor Altitude, Payload Mass, and Velocity



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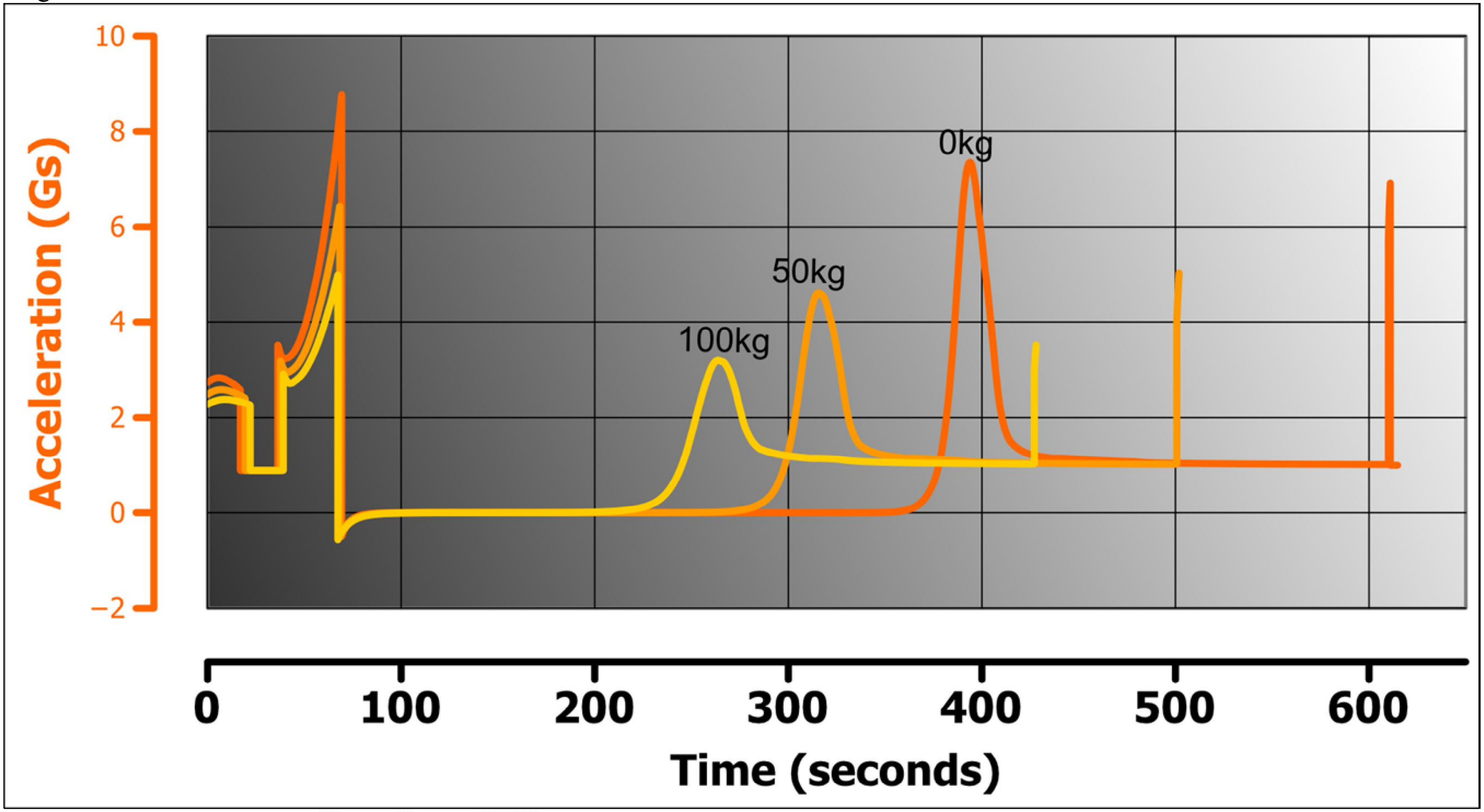
Xogdor Acceleration in Gs



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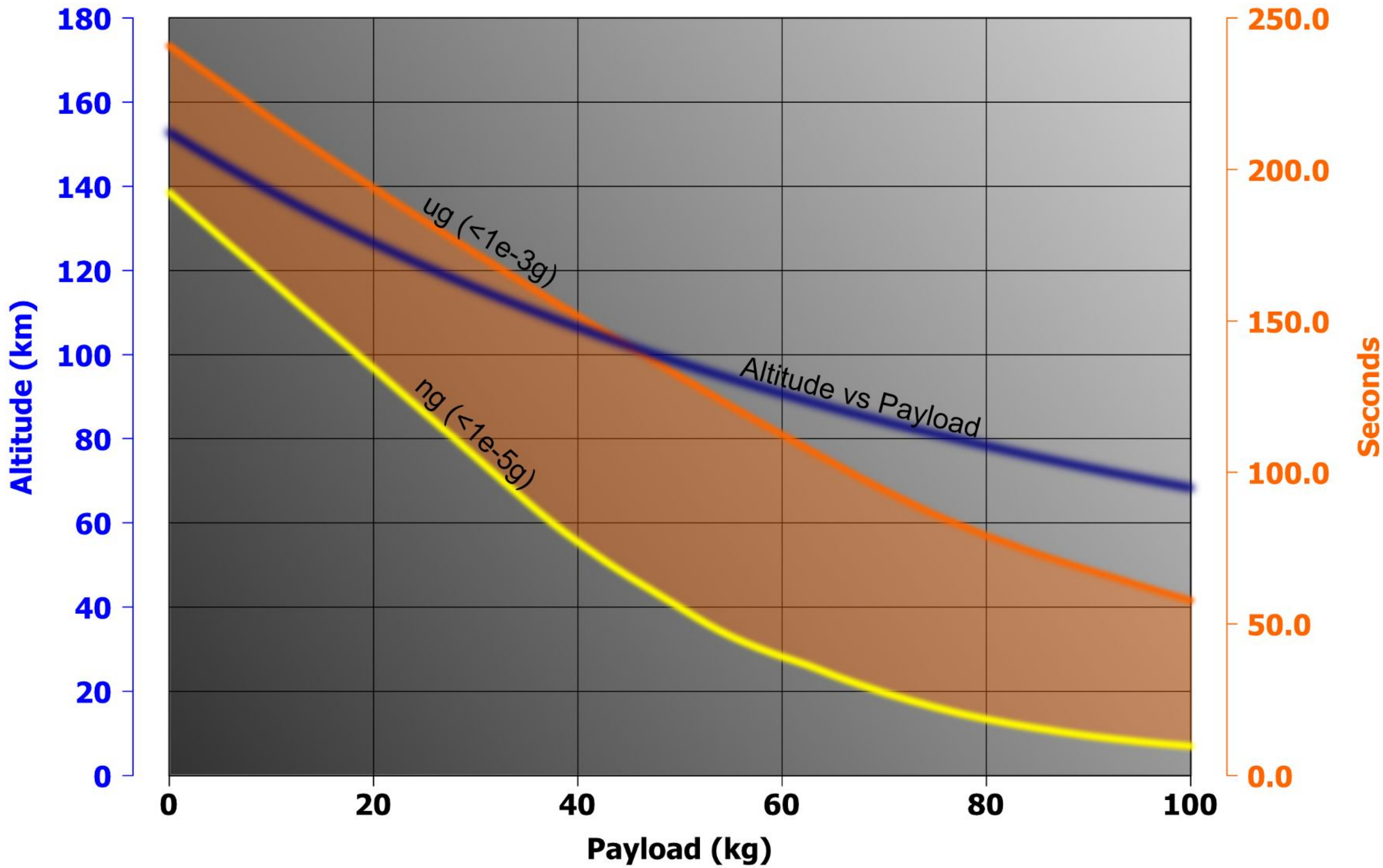
Xogdor Available Microgravity



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